Environmental construction for standardization of elastography and development of viscoelastic phantoms

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Background and Purpose

Elastography:
Non-invasive method for measuring viscoelastic modulus

MRE (Magnetic resonance elastography)
- Using MRI (magnetic resonance imaging)
- Advantages: Deep inside measurements

USE (Ultrasound elastography)
- Using ultrasound system
- Advantages: Real-time measurements

Classification of USE

	Strain imaging	Shear wave imaging
Manual compression	Strain elstography	SWE
Acoustic radiation force impulse excitation	ARFI imaging	Shear wave elastography
Mechanical external vibration		Transient elastography

Issues:
Different elastography systems produce different measurement values. Therefore, the same standard value cannot be used as an imaging biomarker across elastography systems.

Purpose:
Environmental construction for standardization of elastography and development of MRE / USE dual-use phantom

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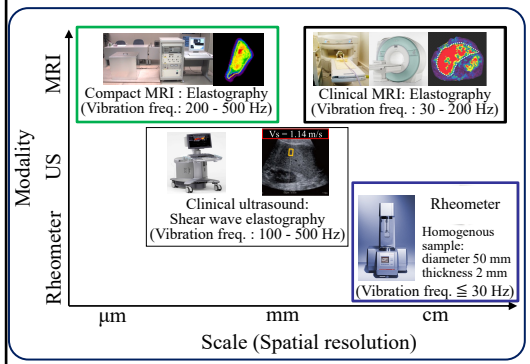
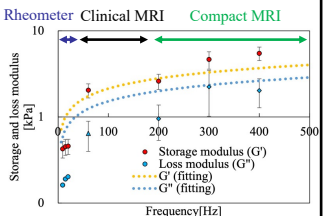
Visco-elasticity Measurement Environment with a Wide Frequency Range of about 1 to 500 Hz



Visco-elasticity measurement environment



Porcine liver (*in-vitro*)
Frequency dispersion

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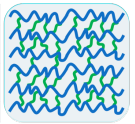
MRE / USE dual-use Tissue-mimicking Viscoelastic Phantom

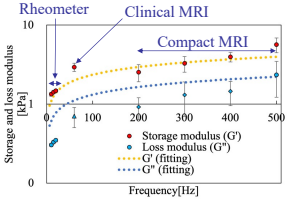
Phantom specification
- Speed of sound: 1560 m/s (QIBA*: 1540 ± 30)
- Attenuation coefficient: 0.5 dB/cm/MHz (QIBA*: 0.5 ± 0.1)

* QIBA US Shear Wave Speed for Liver Fibrosis 2022-04-25

Main chain	Acrylamide
Cross linker	N,N'-Methylenebisacrylamide
Solvent	Water Glycerin (Thickner)
US scatterer	Aluminium oxide



Polyacrylamide gel phantom



Gel phantom
Frequency dispersion

Related papers
- Measuring shear-wave speed with point shear-wave elastography and MR elastography: a phantom study. BMJ Open 2017 Jan 5;7(1):e013925
- Development of a viscoelastic phantom for ultrasound and MR elastography **satisfying the QIBA acoustic specifications**. IEEE IUS 2020, doi: 10.1109/IUS46767.2020.9251680
- **Longitudinal stability** of a multimodal visco-elastic polyacrylamide gel phantom for magnetic resonance and ultrasound shear-wave elastography. PLoS One. 2021 May 21;16(5):e0250667
  - **Shear wave speed (SWS) change -3.6% over 18 months**
- Shear wave speed measurement bias in a viscoelastic phantom across six ultrasound elastography systems: a comparative study with transient elastography and magnetic resonance elastography. J Med Ultrason 2022 Apr;49(2):143-152 , doi: 10.1007/s10396-022-01190-x.

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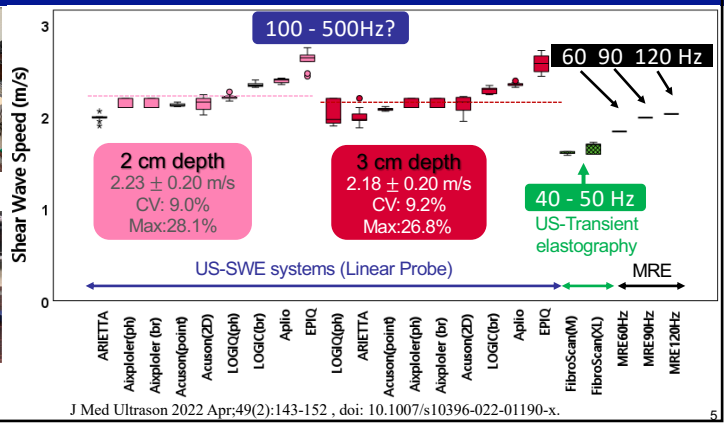
Shear Wave Speed for Different Systems (Linear Probe)



J Med Ultrason 2022 Apr;49(2):143-152 , doi: 10.1007/s10396-022-01190-x.

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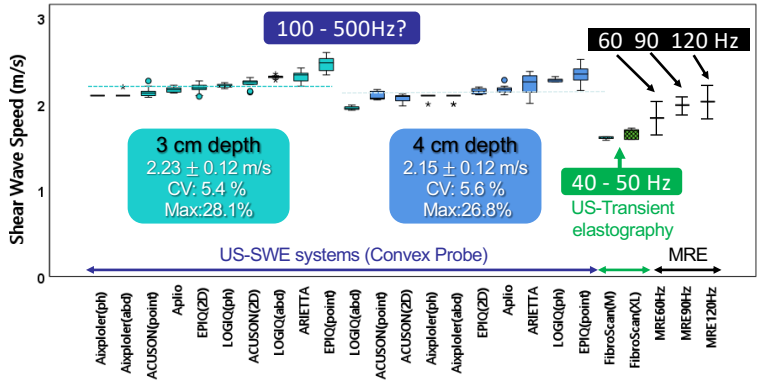
Shear Wave Speed for Different Systems (Convex Probe)



J Med Ultrason 2022 Apr;49(2):143-152 , doi: 10.1007/s10396-022-01190-x.

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Conclusion

- We have constructed a viscoelasticity measurement environment with a wide frequency range of about 1 to 500Hz.
- Our multimodal visco-elastic phantoms for MR and US elastography fulfilled the QIBA specifications, which include the speed of sound, attenuation coefficient, and long-term stability.
- The developed phantoms will help to evaluate the bias and variance between different elastography systems and potentially be used for quality assurance and quality control for MR and US elastography.

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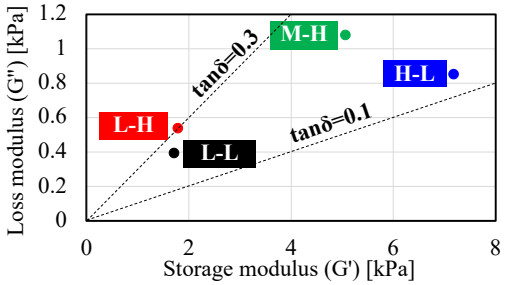
Appendix: Phantoms with Multiple Physical Properties

Various types of polyacrylamide gel phantoms can be made by changing the amounts of acrylamide and N,N'-methylenebisacrylamide.



As an example, the physical properties of four phantoms (measured by research 3D-MRE at 60 Hz)

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